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Experimental Study on Purification Effect of Particulate Matters in FBC+POC Diesel

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Abstract

In the high-sulfur environment and different working conditions with low, mediate and high rotate speed and different torque, the paper has carried out emission experiment of soot particulate matters to study POC, DOC and certain type of FBC. The paper has determined best additive concentration and found that the FBC can replace the DOC and POC to filter the particulate matters reaching national emission standard together.

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Keywords: Particulate oxidation catalyst, diesel oxidation catalyst, additive, smoke opacity, purification effect

1. Introduction

Diesel has been widely used in fields including communication and transportation traffic and engineering machinery due to good dynamic property, economy and low emission of HC and CO_2. However, compared with petrol engine, it is a difficult problem to control of particulate matters. The after-treatment technology is an effective method to reach increasingly strict emission standards. The diesel particulate filter is mature commercial product in the present, which has been used in part of diesel vehicles, but the regenerative problem of filter needs further study.

In order to reach the national emission standard V, some factories have attempted various technical routes to control particulate matters. Now, foreign countries has promoted a new filter device for particulate matters-after-treatment technical route consisted of particulate oxidation catalyst and diesel oxidation catalyst can reduce particulate matters by 48% to 79%, which can meet the requirements of Euro emission standard V. The carriers in the POC are coated with catalysts which have been specially treated. However, seen from the high-sulfur diesel environment in China, the catalysts in the carriers are easy to lose efficacy due to sulfur poisoning. Simple technical route applied in China can hardly reach the national emission standard V. The paper has carried out experimental study to filter particulate matters in the diesel by combining fuel oil additives FBC and POC. The paper aims to replace the DOC+POC by FBC+POC to filter emission of particulate matters in heavy-duty diesel, which can reduce exhaust back pressure of after-

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treatment system to simplify control of after-treatment system and reduce the total cost of after-treatment devices.

2. Testing devices and methods

2.1Testing devices

POC includes two main components: new carrier EcoCat and new low temperature coating KDN1.3. The main function of POC is to oxidize particulate matters in the tail gas, which is the main reason for being named as particulate oxidation catalyst. The main working principle is expressed by the following equations:

$$2NO+O_2 \rightarrow 2NO_2 \quad (1)$$

$$C+2NO_2 \rightarrow CO+2NO \quad (2)$$

$$C+O_2 \rightarrow CO_2 \quad (3)$$

When the soot particulate matters are collected on the carriers of POC, they will carry out oxidizing reaction with NO2 generated from POC. Meanwhile, the unborn HC, soluble particulate matters and CO are also oxidized in POC. When exhaust temperature is between 200℃ and 550℃, the carriers in POC will carry out reaction as equation (1) and equation (2). When exhaust temperature is above 550℃, the carriers in POC will carry out spontaneous combustion as equation (3) for exhaust temperature reaches ignition temperature of particulate matters.

The engine used in the test is Steyr WD615-96 produced by Sinotruk Group meeting with national emission standard III. The after-treatment system mainly includes DOC and POC (as figure 1), and U tube mercury differential pressure gauge is connected inlet of exhaust in the after-treatment system, where are located with pressure sensor to measure exhaust pressure. The Nanhua NH-1 type light obscuration gauge in the test is used to measure the smoke opacity of exhaust in the inlet and outlet. Besides, exhaust pressure and exhaust temperature collected by pressure sensor and temperature probe are stored in data acquisition system.

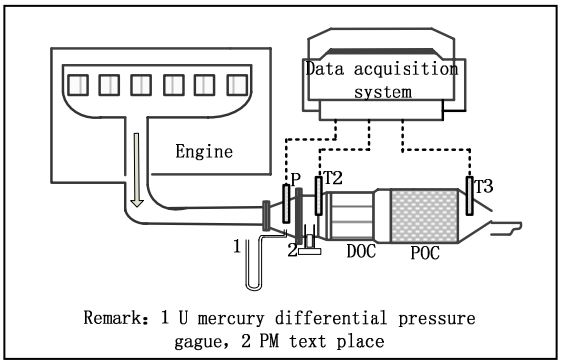

Figure 1 System diagram of test devices.

2.2Testing methods

The testing oil in the study is common 0# diesel oil in the market with the sulfur concentration from 1300ppm to 1500ppm. Additives are certain HC solvents with iron elements developed by Singapore

Infineum. In conditions with low, medium and high rotate speed (1000r/min, 1400r/min, 1800r/min) and different torque (200N • m ~ 600N • m), the particulate matters in exhaust are filtered by additives, POC and DOC. During the test, the additives of certain concentration are added into fuel oil directly, and mixed together by fully stirring. Exhaust temperature, exhaust pressure and smoke opacity in the inlet and outlet of exhaust are collected by various relevant sensors after the test enters steady working conditions.

3. Testing results and analysis

The study uses PM purification efficiency and smoke opacity in the outlet of exhaust to evaluate effect that DOC and additives together with POC respectively filters emission of particulate matters. The purification efficiency of PM is calculated by smoke opacity in the same working condition.

$$\eta = \frac{R_{in} - R_{out}}{R_{in}} \times 100\% \tag{4}$$

In the equation, is smoke opacity in the inlet of exhaust, and is the smoke opacity in the outlet of exhaust.

We have carried out soot filtering test by combining POD with additives with different concentration to measure smoke opacity in the inlet and outlet of POC and calculate the purification efficiency in the condition. As a result, we can evaluate the purification effect of FBC/POC on particulate matters. In order to make comparison, we have tested DOC+POC design together to judge whether FBC can replace DOC.

Figure 2 and figure 3 are purification effect on particulate matters from FBC of different concentration in fuel oil under working condition of 1000r/min. It can be known from the figures that the purification effect is high in 90ppm, and the purification effect decreases rather than increases when the concentration of additives increases. It can be seen from the smoke opacity in the outlet of exhaust that the smoke is the least in 90ppm, which has better effect than DOC+POC. Therefore, 90ppm additives can replace DOC under the rotate speed.

It can be also seen from figure 2 that when additives are 90ppm and working condition of 200N.M, the purification efficiency is not as good as in DOC+POC design. This is because the principle of additives oxidizing soot and principle of DOC oxidizing soot are different. The principle of additives is that catalysts can decrease activation energy in soot and oxidation reaction, with obvious catalytic action above 350℃ and low effect in low temperature. DOC oxidizes soot through mediate reactants NO_2 with obvious effect above 250℃.

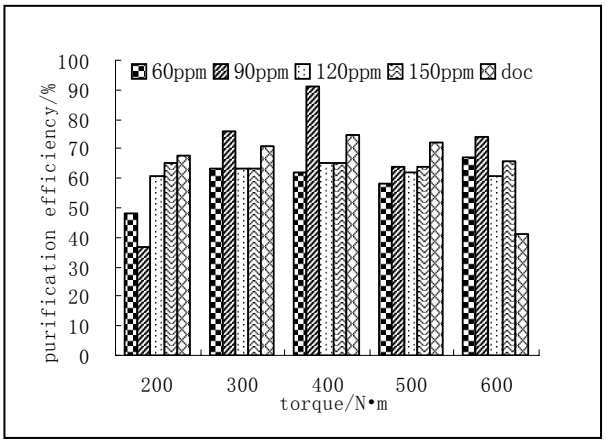

Figure 2 Purification efficiency of FBC/POC on soot in 1000r/min.

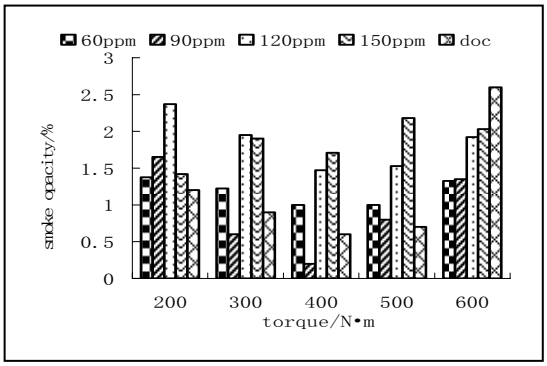

Figure 3 Soot emission of FBC/POC in 1000r/min .

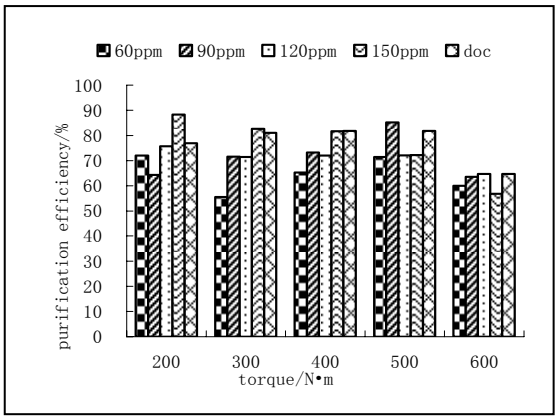

Figure 4 Purification efficiency of soot in 1400r/min.

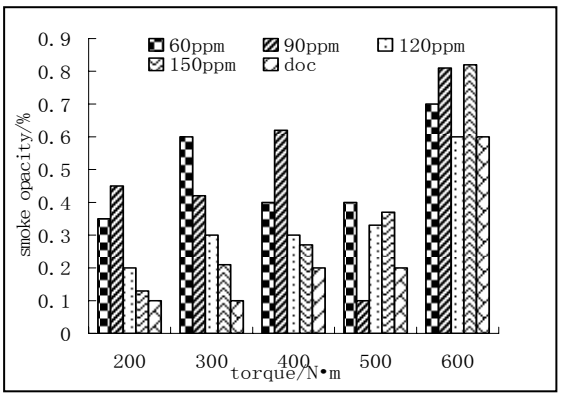

Figure 5 Soot emission in 1400r/min.

Figure 4 and figure 5 are purification effect on particulate matters from FBC of different concentration and POC and variation diagram of soot emission in the outlet of exhaust under working condition of

1400r/min. It can be known from the figures that the purification effect of additives generally is worse than DOC under the rotate speed. However there are few differences between the two methods. The additives can obtain best effect with concentration of 90ppm, and the purification effect is better than DOC or as good as DOC in certain working conditions. It can be seen from the smoke opacity that the general law is the same. The increased additives can not decrease the smoke opacity in the outlet of exhaust. Under various working condition of the rotate speed, the effect that FBC/POC filters soot particulate matters in the tail gas and the effect that DOC+POC filters soot particulate matters in the tail gas are almost the same. Figure 6 and figure 7 are purification effect on particulate matters from FBC of different concentration and POC and variation diagram of soot emission in the outlet of exhaust under working condition of 1800r/min. It can be known from the figures that the purification effect of additives generally is good with concentration of 90ppm. It can be seen from soot emission in the outlet of exhaust that the differences in smoke opacity are few, and the effect of additives are good, which has better effect with concentration of 90ppm.

It can be seen from figure 6 that soot purification efficiencies are high then. The reason may be the exhaust temperature is high (280℃) in the working condition which is good for catalysts to perform its catalytic action. At the same time, the soot purification efficiency decreases with the increase of soot emission. When soot emission is large (i.e., 600N.m), due to the processing capacity of POC on soot, parts of soot will be discharged directly from POC, which can be known from smoke opacity in the outlet of exhaust.

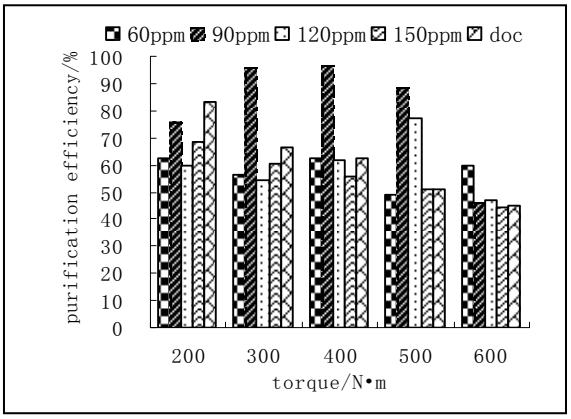

Figure 6 purification efficiency of soot in 1800r/min.

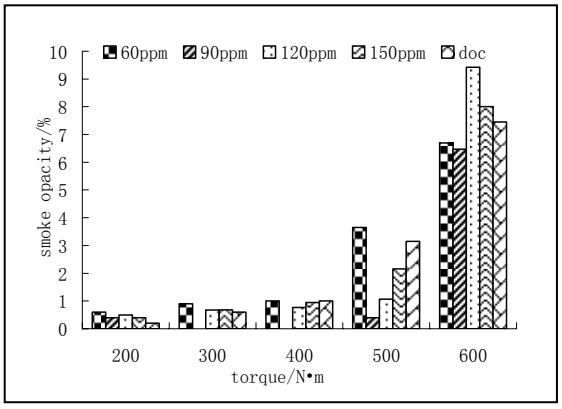

Figure 7 Soot emission in 1800r/min.

4. Conclusions

The cost of after-treatment devices can be greatly reduced and the sulfur poisoning and aging problem in DOC can be avoided if we replace the DOC by FBC to carry out oxidation regeneration to soot particulate matters in POC. The method has great practical applicability.

According to the above experiment, we can bring out the following conclusions:

a) When PM is filtered by additives and POC together, high additive concentration can not obtain better effect. The additive concentration increases to certain degree resulting in worse effect.

b) In the study of the paper, additives FBC can replace DOC to filter soot particulate matters with POC, and the concentration of FBC is 90ppm.

c) Sulfur concentration has obvious influences on filtering soot particulate matters in the exhaust of diesel by after-treatment devices. The additives added in the fuel oil can solve the poisoning problem of catalysts in the carriers.

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References

[1]Zhang Chunrun, Zi Xinyun, He Yu etc. Diesel particle emission control technology[Z]. National Scientific and Technological Achievements. 2003

[2]K.Lehtoranta,P.Matilainen,J.M.Åsenbrygg,et al Particle oxidation cata- lyst in light duty and heavy duty die- sel applications[C].SAE Paper 2007- 24-0093.

[3]Ingolf Reverencic.Emission Eevelo- opment for Euro4 and Beyond Alterna- tive strategies with exhaust gas aftertreatment[C].Bei-jing 2006 Fo- rum on Sustainable Development of In- ternal Combustion Engines,2006:2-9.

[4]Aulis Vakkilainen and Reijo Lylyka- ngas. Particle Oxidation Catalyst (POC) for Diesel Vehicles[C].SAE Paper 2004-28-0047.

[5]Zi Xinyun, Yao Guangtao etc. Heavy diesel state Ⅳ emission techniques research report[M]. Military Transportation University 2009[M]. Military Transportation University2009.

[6]Zi Xinyun, Zhang Chunrun, Yao Guangtao etc. Technology research report[M] . Military Transportation University2010.